of flow to the parallel microchannels is preferably equally distributed with less than 35% (25%, 10%) difference in mass flowrate per channel.

[0040] The inventive apparatus may exhibit superior results for processes involving heterogeneous catalysis or heat transfer at Re above 100.

[0041] In another aspect, the invention provides microchannel apparatus, comprising: a microchannel comprising a microchannel wall comprising surface features in a staggered herringbone mixer (SHM) configuration wherein the SHM has spaces between angled surface features; and fill features situated in the spaces.

[0042] In a still further aspect, the invention provides a method of fluid processing in a microchannel, comprising: providing microchannel apparatus comprising a microchannel;

[0043] wherein the microchannel comprises two opposing microchannel walls and a gap between the two opposing microchannel walls; wherein at least one of the microchannel walls comprises at least 10 similar surface features in series; wherein each of the similar surface features comprises at least one angle and a ratio of surface feature depth:channel gap of at least 0.4; and flowing a fluid through the microchannel at a Re of more than 100.

[0044] In some preferred embodiments, there is a catalyst or sorbent disposed on the surface features. In some preferred embodiments, there is a heat sink or heat source contacting the microchannel wall having a series of similar surface features. In many preferred embodiments, the inventive methods are operated at short contact times and/or high Reynold's numbers (Re) and/or high Pe (Peclet numbers).

[0045] In another aspect, the invention provides a method of fluid processing in a microchannel, comprising: flowing fluid through a microchannel at a Reynold's number Re of more than 100; wherein the microchannel comprises surface features; and performing a unit operation on the fluid in the surface features. The unit operation can be any of the unit operations discussed herein but not solely mixing (although mixing typically often occurs along with other unit operations).

[0046] In another aspect, the invention provides a method of fluid processing in a microchannel, comprising: passing a fluid through a channel inlet into a microchannel;

[0047] wherein the microchannel comprises surface features in at least one surface feature section; where more than 30% (more preferably at least 50%, 75%, or 90%) of the inlet mass of fluid enters the volume of the at least one surface feature in the surface feature section; performing a unit operation on the fluid in the surface feature section. The mass of fluid that enters the surface features is determined according to methods and descriptions provided herein.

[0048] In a further aspect, the invention provides a method of fluid processing in a microchannel, comprising: providing microchannel apparatus comprising a microchannel; wherein the microchannel comprises surface features; wherein the surface features comprise at least 1 angle in each surface feature; and wherein a heat sink or heat source is in thermal contact with the active surface features. A fluid is passed through the microchannel at a Re of more than 100 resulting in heat transfer to or from the fluid flowing in the microchannel. Preferably, the heat sink or heat source comprises a heat exchanger that preferably comprises microchannels.

[0049] In another aspect, the invention provides a method of fluid processing in a microchannel, comprising: providing microchannel apparatus comprising a microchannel; wherein the microchannel comprises a microchannel wall that comprises a section comprising surface features in thermal contact with a heat source or a heat sink; flowing a fluid through the microchannel and exchanging heat through the at least one microchannel wall between the fluid and the heat source or sink; wherein a pressure drop occurs over the section comprising surface features; and wherein the heat transferred in the section divided by the heat transferred under identical conditions in a featureless section (h_{SF}/h_o) is at least 1.1 times as great as the pressure drop in the section divided by the pressure under identical conditions in a featureless section (dP_{SF}/dP_o). A "featureless section" is not another section in the same device that doesn't have features, but it is a simulated (by experiment or calculation) device identical to the section, except that the features are replaced with walls. The invention also includes apparatus characterized by the same heat transfer improvements as measured by the techniques described herein.

[0050] In a further aspect, the invention provides a method of fluid processing in a microchannel, comprising: providing microchannel apparatus comprising a microchannel; wherein the microchannel comprises a first section and a second section; wherein the first section comprises a first series of surface features; wherein the second section comprises a second series of surface features; and passing a fluid through the microchannel such that flow is mixed in the first and second sections, but relaxes to substantially parabolic flow between the sections. In a preferred embodiment, the first series of surface features have different characteristics than the second series (for example, different average feature depths—although any of the characteristics described here could be selected). In some embodiments, a first unit operation occurs in the first section and a different unit operation occurs in the second section.

[0051] In another aspect, the invention provides a method of making a laminated microchannel article, comprising: stacking a first sheet with see-through surface features adjacent to a sheet comprising a microchannel such that the see-through surface features are disposed on one side of the microchannel; and stacking a second sheet comprising cavities adjacent to the first sheet such that a cavity on the second sheet is adjacent to at least one see-through feature on the first sheet. The cavity can be a see-through feature. The invention also includes apparatus made by any of the techniques described herein.

[0052] In still another aspect, the invention provides a method of washcoating a microchannel, comprising: providing a microchannel comprising plural similar, repeating surface features, wherein the similar, repeating surface features comprise at least 1 angle in each similar surface feature; and applying a washcoat over the plural similar, repeating surface features.

[0053] The inventors have discovered improved performance by using relatively deep features. For example, features that have a depth that is at least 20% of the gap distance between opposing microchannel surfaces; in some